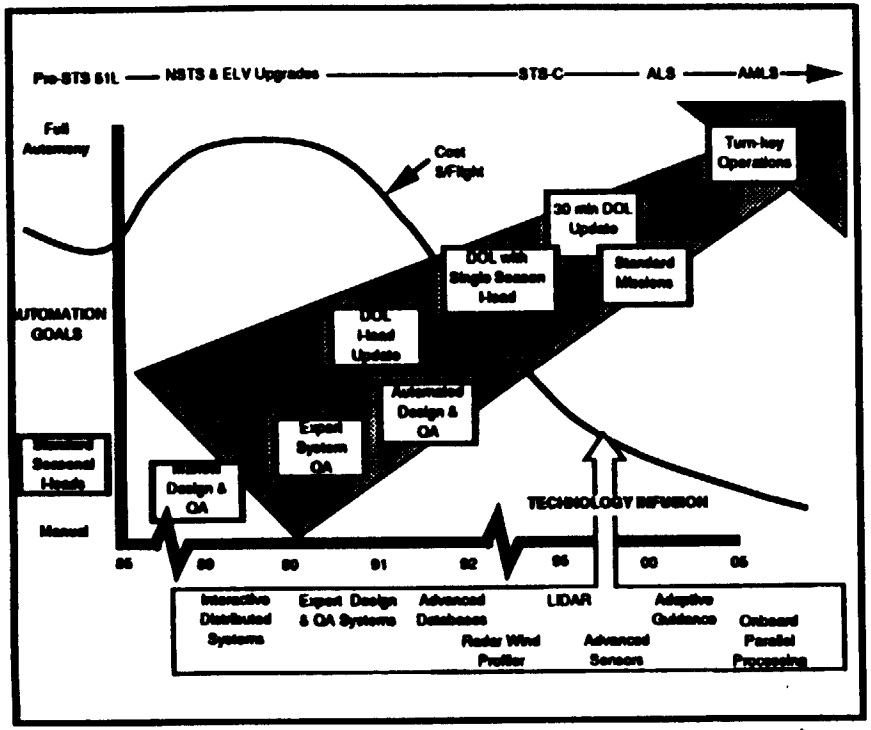
OPERATIONAL EFFICIENCY

SPACE TRANSPORTATION TECHNOLOGY SYMPOSIUM
OPERATIONAL EFFICIENCY
AUTOMATIC ASCENT FLIGHT DESIGN

NOVEMBER 1989



MAJOR OBJECTIVES

- Enhance Hardware and Software with New Automated Design Tools and Distributed Equipment
- Reduce Costs
- Increase Launch Probability
- Improve Flight Design Quality Assurance
- Reduce Flight Design Timeline / Increase Responsiveness
- Standardized Training Techniques and Tools
- Develop Onboard Targeting & Autonomous Guidance

KEY CONTACTS

- E. M. Henderson - JSC / DM
  - Rockwell Shuttle Operations Co.
- A. J. Bordano - JSC / FM
  - McDonnell Douglas Space Systems Co.

Facilities:

- Flight Design Computational Facility - JSC / DM
  - Flight Analysis and Design System (FADS)
- MPAD Prototyping Lab - JSC / FM
- Shuttle Avionics Integration Lab (SAIL) - JSC / EA

MAJOR MILESTONES (1990-2005)

Technology Availability:	Products:	
• Interactive / Distributed Systems		Today
• Flight Design Expert Systems	• Day of Launch I-load Update	1990
• Advanced DB's for Flight Design		1991
	• Expert System I-load Verif.	
	• Auto I-load Design	1992
• Radar Wind Profiler	• FADS	1993
	• FSW for single season I-load	
• Adaptive Guidance Algorithms		1995
• LIDAR Technology		1997
• Advanced Sensors	• 30 min DOL I-load Design	1998
• Flight Qualified Parallel Proc.		2000
	• Onboard Autonomy	2005

SPACE TRANSPORTATION TECHNOLOGY SYMPOSIUM
OPERATIONAL EFFICIENCY
AUTOMATIC ASCENT FLIGHT DESIGN

NOVEMBER 1989

TECHNOLOGY ISSUES

- Distributed Processing
- Advanced Software / Database Technology
- Ground vs. Onboard Automation
- Ground vs. Onboard wind sensing/processing
- Advanced Sensors/Processing
  - Winds
  - Air Loads
  - Air Data
- Autonomous Abort Capability
- Onboard Parallel Processing for GN&C applications

CANDIDATE PROGRAMS

- STS / STS Evolution / ASRM
- ELV'S
- STS - C
- ALS
- AMLS
- Lunar / Mars Initiative

MAJOR ACCOMPLISHMENTS

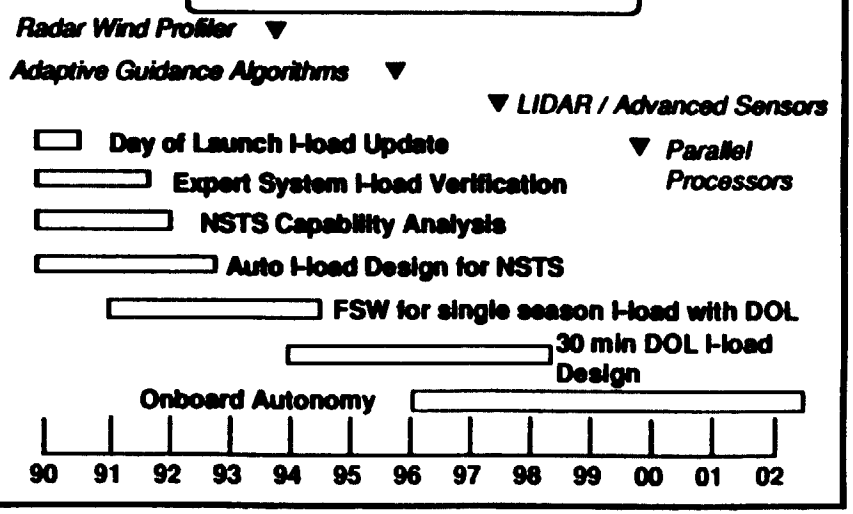
Implemented

- Alternate Iloads
- Adaptive Guidance Throttling

Demonstrated Capability

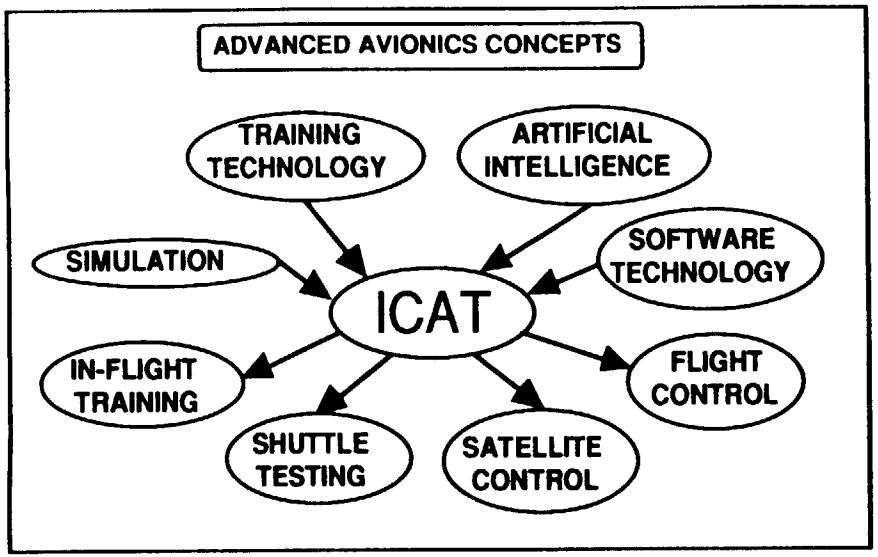
- Automated Day-of-Launch I-load generation & verification
- Automated Flight Design verification (partial)
- Single Season I-load for NSTS
- Onboard Targeting Algorithm for NSTS

SIGNIFICANT MILESTONES



SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
OPERATIONAL EFFICIENCY
ADVANCED TRAINING SYSTEMS

NOVEMBER 1989



MAJOR OBJECTIVES:

DISTRIBUTED INTELLIGENT SYSTEMS FOR TRAINING IN COMPLEX, MISSION-CRITICAL TASKS THAT

- ARE ADAPTIVE TO INDIVIDUAL PERFORMANCE
- UTILIZE ADVANCED GRAPHICS
- PROVIDE UNIFORM AND VERIFIABLE TRAINING TO ENHANCE SAFETY
- ARE EASILY MAINTAINED

KEY CONTACTS:

JSC:	ROBERT T. (BOB) SAVELY FRANK HUGHES
KSC:	TOM DAVIS ASTRID HEARD
MSFC:	MICHELLE PERRIN
GSFC:	WALT TRUSZKOWKSI
HQ:	GREGG SWIETEK CHUCK HOLLIMAN

MAJOR MILESTONES (1990-1995):

- 1990: GENERAL ARCHITECTURE FOR ICAT SYSTEMS
- 1991: INTERFACE DEV. TOOLS
- 1992: KNOWLEDGE ACQUISITION TOOLS
- 1993: TOOL INTEGRATION
- 1994: TESTING AND DELIVERY OF GENERAL-PURPOSE ICAT DEV. ENVIRONMENT

SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
OPERATIONAL EFFICIENCY
ADVANCED TRAINING SYSTEMS

NOVEMBER 1989

TECHNOLOGY ISSUES:

- AUTOMATION OF KNOWLEDGE ACQUISITION PROCESS
- HARDWARE FOR IN-FLIGHT ICAT SYSTEMS
- INTEGRATION WITH EXISTING SIMULATION SYSTEMS

CANDIDATE PROGRAMS:

CURRENT ICAT PROJECTS:

- FLIGHT CONTROL (JSC)
- SHUTTLE TESTING (KSC)
- SPACELAB SYSTEMS (MSFC)
- SATELLITE CONTROL (GSFC)
- IN-FLIGHT SYSTEMS (SHUTTLE AND SPACE STATION)

MAJOR ACCOMPLISHMENTS:

- OPERATIONAL ICAT SYSTEM FOR JSC FLIGHT CONTROLLERS
- TESTING WITH TRAINEE FLIGHT CONTROLLERS HAS SHOWN SIGNIFICANT IMPROVEMENTS IN TIME ON TASK WITH AN CONCURRENT DECREASE IN ERRORS
- ICAT SYSTEMS DELIVERABLE IN WORKSTATION ENVIRONMENTS

SIGNIFICANT MILESTONES:

- NASA AND UNIV. AI R&D PROVIDE TECHNOLOGY BASE FOR ICAT SYSTEMS
- CODE MD AND ST SUPPORT ICAT ARCHITECTURE AND DEV. ENVIRONMENT PROJECTS
- OPERATIONAL CENTERS SUPPORT SPECIFIC ICAT APPLICATION DEVELOPMENT

SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
OPERATIONAL EFFICIENCY ADVANCED TRAINING SYSTEMS

NOVEMBER 1989

ADVANCED TRAINING SYSTEMS (ATS)

- EVOLVE IN CONTEXT OF STS UPGRADE STRATEGY
- STRATEGIC PLAN USES COMMERCIAL PRODUCTS, ADVANCED TECHNOLOGY, SSF COMPONENTS
- SELECT APPLICATIONS HAVE BEEN SUCCESSFULLY INTRODUCED AND DEVELOPED IN STS ONBOARD SPACE SYSTEMS
- SIGNIFICANT TECHNOLOGICAL ADVANCEMENT IN NEAR-TERM APPLICATIONS

MAJOR OBJECTIVES:

- LOW COST (DEVELOPMENT, IMPLEMENTATION)
- REUSE OF TRAINING MECHANISMS
  - ACROSS PROGRAM ELEMENTS
  - ACROSS PROGRAMS
- REDUCED SUPPORT INFRASTRUCTURE
  - DDT&E
  - OPERATIONAL
- SUPPORT FUTURE TECHNOLOGY UPGRADES
- SUPPORT UPGRADE AND TRANSFER OF SKILLS
- SUPPORT CAPTURE AND USE OF DDT&E INFORMATION IN THE OPERATIONS PHASE

KEY CONTACTS:

TONY MACINA	/IBM
ED CHEVERS	/JSC
ELRIC MCHENRY	/JSC
SAM ANKNEY	/JSC
JUDY N CHISWELL	/SEI

FACILITIES:

JSC SDF
IBM INTERNAL

FUTURE FACILITIES

JSC SPF
JSC SAIL
JSC TRAINERS
KSC LPS

MAJOR MILESTONES (1986 - 1992)

- REVIEW TECHNOLOGY (1986)
- BUILD PROTOTYPES, SELECTIVE USE TO DEMONSTRATE MATURITY (1987)
- INTRODUCE SUCCESSFUL APPROACHES INTO OPERATIONAL USE (1988)
- ESTABLISH STRATEGIC STS ADVANCED TRAINING PLAN (1989)
- RECONCILE PLAN WITH SSP STRATEGIC PLAN (1990)
- INTRODUCE JOINT PROTOTYPE INTO JSC LAB (1991)
- BEGIN INTRODUCTION INTO SUPPORT INFRA STRUCTURE (1992)

SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
OPERATIONAL EFFICIENCY ADVANCED TRAINING SYSTEMS

NOVEMBER 1989

TECHNOLOGY ISSUES:

- TECHNOLOGY INTRODUCTION INTO STABLE OPERATIONAL ENVIRONMENT
- INTRODUCTION OF COMMON ARCHITECTURE INTO EXISTING DIVERSE SET
- CULTURAL AND ORGANIZATIONAL CHANGES OF EXISTING ENTITIES

CANDIDATE PROGRAMS:

STS

STS UPGRADE

SPACE STATION PROGRAMS

SHUTTLE C

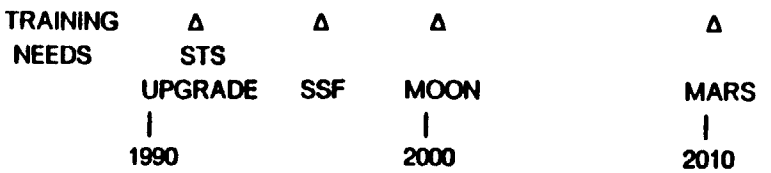
MAJOR ACCOMPLISHMENTS:

- TECHNOLOGY MATURITY DEMONSTRATED
- SUCCESSFUL ENTRY INTO SELECT OPERATIONAL AREAS
- CURRENT SSP APPROACHES APPEAR COMPATIBLE
- POTENTIAL FOR USE IN FOLLOW ON PROGRAMS (LUNAR BASE, MARS LANDING)

SIGNIFICANT MILESTONES:

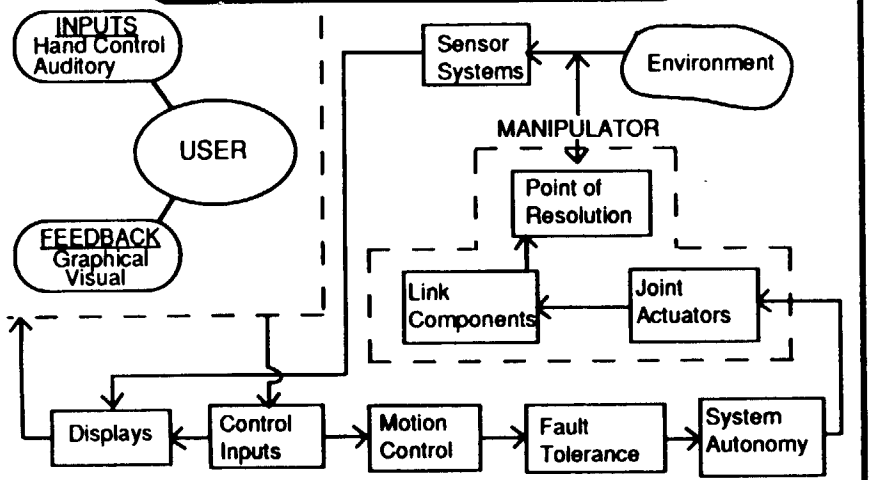
- ADVANCED TRAINING SYSTEMS PLAN
- RECONCILE PLAN WITH SSP
- INTRODUCE JOINT PROTOTYPE INTO SS LAB
- INTRODUCE INTO SUPPORT INFRASTRUCTURE

INFRASTRUCTURE TRAINING UPGRADES



SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
OPERATIONAL EFFICIENCY
TELEROBOTICS / TELEPRESENCE

TELEROBOTICS / TELEPRESENCE



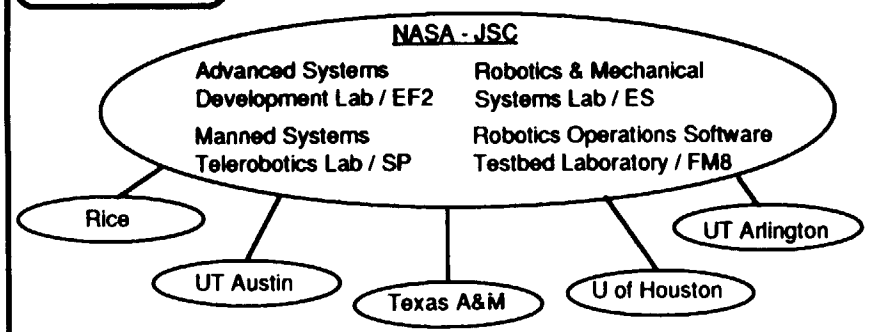
MAJOR OBJECTIVES:

* Extend manned presence in space
  - Allow operations in locations not accessible by man
  - Provide for operations under hazardous conditions
  - Extend operations timelines by eliminating EVA restrictions
* Enable significant unmanned / autonomous operations
* Enhance crew safety
  - Minimize requirements for EVA
  -Reduce crew exposure to hazards
* Enhance crew time effectiveness
* Utilize current technology for prototype systems
* Provide capability to incorporate new technology as available
* Enhance commonality among in-flight, crew training, and engineering analysis systems

KEY CONTACTS:

C. Gott / FM8
C. Price / EF2
L. Stokes / ES
L. Quiocho / FM8
J. LeGendre / SP

FACILITIES:



NASA / UNIVERSITY TELEROBOTICS LABORATORY NETWORK

MAJOR MILESTONES (1990 - 1995)

* Advanced RMS Control (1991)
* NASA / University Telerobotics Lab Network Demo (1992)
* SRMS Manipulator Controller Interface Unit (MCIU) Upgrade (1992)
* Fault Tolerant Manipulator Prototype Demo (1992)
* Dexterous Manipulator Demonstrations Flight Experiment (1992)
* Mobile Servicing Centre Flight Articles in JSC's Integrated Test Facility (SSAIAF) (1993)
* Fault Tolerant Manipulator Flight Hardware (1994)

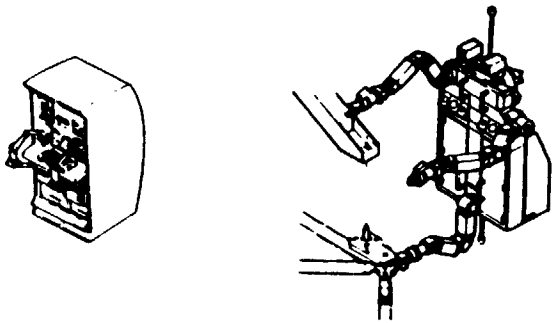
SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM

OPERATIONAL EFFICIENCY

TELEROBOTICS/TELEPRESENCE (FTS)

NOVEMBER 1989

ADVANCED AVIONICS CONCEPTS



MAJOR OBJECTIVES:

FLIGHT TELEROBOTICS SERVICER (FTS)

- TELEROBOTIC SYSTEM USED FOR ASSEMBLY, MAINTENANCE, SERVICING, AND INSPECTION
- USE ON NSTS, SPACE STATION, OMV
- SPACE STATION FTS PLANNED FOR INDEFINITE LIFETIME WITH PERIODIC SERVICING AND UPGRADE

KEY CONTACTS:

H. MCCAIN/GSFC
K. HALTERMAN/GSFC
J. LOWRIE/MMC
J. DAVIDSON/MMC

FACILITIES:

GSFC ROBOTICS LAB
MARTIN MARIETTA FACILITIES, DENVER, COLORADO

MAJOR MILESTONES (1990 - 1995):

FTS MISSIONS

- NSTS DEVELOPMENT TEST FLIGHT-1 - 1991
- NSTS DEMONSTRATION TEST FLIGHT-2 - 1993
- SPACE STATION FIRST ELEMENT LAUNCH - 1995

SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM

OPERATIONAL EFFICIENCY

TELEROBOTICS/TELEPRESENCE (FTS)

NOVEMBER 1989

TECHNOLOGY ISSUES:

- EVOLUTION OF OPERATIONAL TELEROBOT INTO AUTONOMOUS ROBOT
- INCORPORATE NEW TECHNOLOGIES AS THEY BECOME MATURE

CANDIDATE PROGRAMS:

- COMPUTER THROUGHPUT
- ALGORITHM DEVELOPMENT
- SENSORS
- VISION PROCESSING
- PATH PLANNING
- MODELS

MAJOR ACCOMPLISHMENTS:

- SELECTION OF NASREM FUNCTIONAL ARCHITECTURE
- RELEASE OF FTS EVOLUTION PLAN APRIL 1989
- EXECUTION OF FTS PRIME CONTRACT WITH MARTIN MARIETTA, JULY 1989

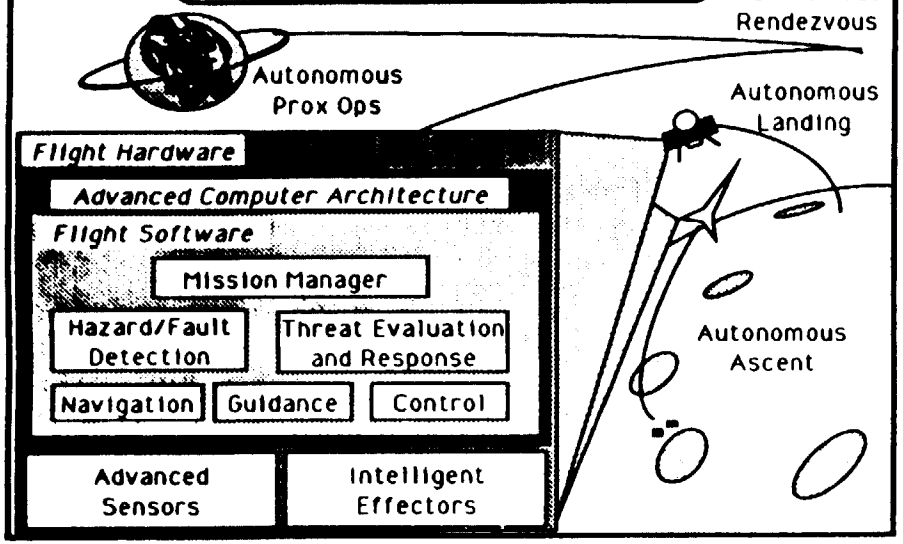
SIGNIFICANT MILESTONES:

- SHORT TERM EVOLUTION (< 5 YEARS) IMPROVE TELEPRESENCE
- LONG TERM EVOLUTION (> 5 YEARS) AUTONOMY

SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
OPERATIONAL EFFICIENCY
AUTONOMOUS SPACECRAFT CONTROL

November 1989

ADVANCED AVIONICS CONCEPTS



MAJOR OBJECTIVES:

- Increase spacecraft autonomy
  - Reduce dependence on ground systems
  - Enable remote operations
- Reduce cost of spacecraft operations
  - Improve hardware/software commonality and modularity
  - Improve propellant efficiency
- Improve spacecraft reliability and mission readiness
  - Autonomous planning for time-limited missions
  - Reduce crew workload
- Enhance mission success probabilities and performance
  - Improve capability to survive on-board failures
  - Provide for task adaptation based on unanticipated changes in operating environment
  - Increase maneuver accuracy
  - Reduce plume impingement/contamination
- Reduce development risk

KEY CONTACTS:

K. Baker/JSC - Autonomous Landing
C. Gott/JSC - Autonomous Rendezvous
R. Kahl/JSC - MRSR Study
S. Lamkin/JSC - Pathfinder AR&D
J. Lamoreux/JSC - AR&D and Landing Sensors
J. Moore/JSC - Satellite Servicer System
R. Savely/JSC - Artificial Intelligence

FACILITIES:

- JSC Integrated Graphics Operations Assessment Laboratory (IGOAL)
- JSC Autonomous Operations Testbed (AUTOPS)
- JSC Tracking Test Bed / 6-DOF Positioner
- JSC Manipulator Development Facility
- JSC & MSFC Air Bearing Floor Facilities
- JSC Hybrid Vision Laboratory

MAJOR MILESTONES (1990 - 1996)

- Review technologies (1989-1990)
- Develop most critical and beneficial technologies and techniques (1990-1993)
- Demonstrate autonomous rendezvous, docking and proximity operations (1993-1994)
- Ground/atmospheric flight demonstration of autonomous landing and hazard avoidance sensors/processor technologies and techniques (1994-1996)

SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
OPERATIONAL EFFICIENCY
AUTONOMOUS SPACECRAFT CONTROL

November 1989

TECHNOLOGY ISSUES:

- Degree of autonomy
  - Sensing and perception
  - Intelligent control
  - Supervised actuation
  - Task planning and management
- Role of artificial intelligence (AI) technology
- Tracking/Vision sensing techniques and Systems for AR&D and L
  - Navigation
  - Debris Avoidance
- Interactions with ground and manned systems
  - Command and control
  - Effects of communications time-lag
- System architecture and integration
  - Distributed computing and parallel processing
  - Cooperating expert systems
  - Location of sensor data processing
- System performance and reliability

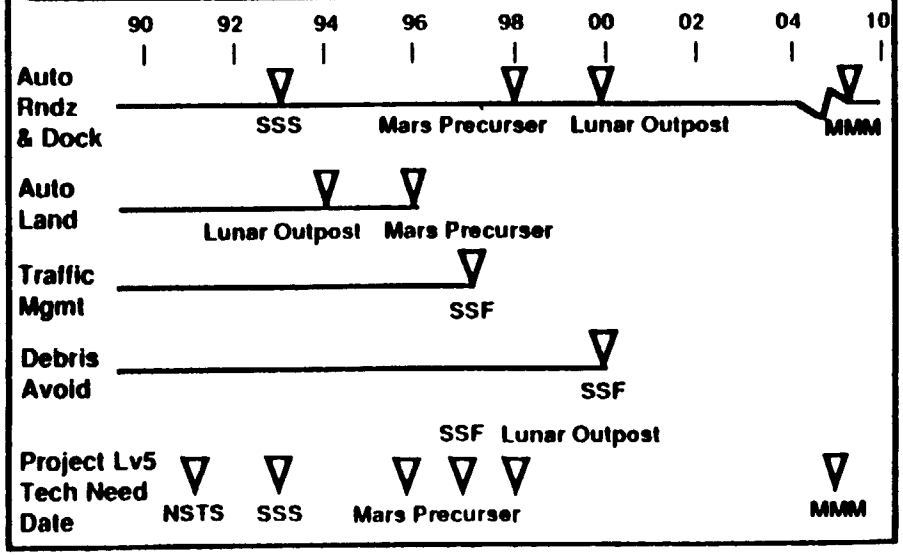
CANDIDATE PROGRAMS:

- NSTS
- Space Station Freedom (SSF)
- Satellite Servicer System (SSS)
- Crew Emergency Return Vehicle
- Heavy Lift Cargo Delivery Systems
- Orbital Maneuvering Vehicle (OMV)
- Orbital Transfer Vehicle (OTV)
- Aero-assist Orbital Transfer Vehicle (AOTV)
- Autonomous Free-Flyers
- Mars Rover/Sample Return
- Manned Lunar Base
- Manned Mars Mission (MMM)

MAJOR ACCOMPLISHMENTS:

- Autonomous Operations (AUTOPS) testbed development
- On-orbit operations knowledge capture
- Technology investigations in improved on-orbit algorithms and system and environment model
- Ladar being developed for SSS flight demonstration
- 3D Range/Doppler imager and processor in development
- Hybrid image processing in development
- Pathfinder technology studies in progress
- Definition of radio tracking navigation from lander to orbiter for accurate landing

SIGNIFICANT MILESTONES:



SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
OPERATIONAL EFFICIENCY
AUTONOMOUS SPACE CRAFT CONTROL

ADVANCED AVIONICS CONCEPTS

Tracking & Guidance Sensor with active Illumination

RMS Docking Target Augmented with retro-reflective material

MAJOR OBJECTIVES:

- Low cost
- Low complexity
- Requires only a passive target
- Capable of operating in a variety of scenarios

KEY CONTACTS

E.C. Smith/MSFC

F. Dabney/MSFC

R. Howard/MSFC

S. Lamkin/JSC

FACILITIES

MSFC Flight Robotics Laboratory

MAJOR MILESTONES (1990-1995):

- Test current technology (1990)
- Complete development of advanced applications (1991)
- Analysis and large scale hardware demonstration (1991)

SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
OPERATIONAL EFFICIENCY
AUTONOMOUS SPACE CRAFT CONTROL

TECHNOLOGY ISSUES:

- Sensor range: moving parts vs. reliability
- Self-monitoring system to detect malfunctions

CANDIDATE PROGRAM:

- OMV
- Shuttle C
- Space Station
- MARS Rover-Sample Return
- Satellite Servicing

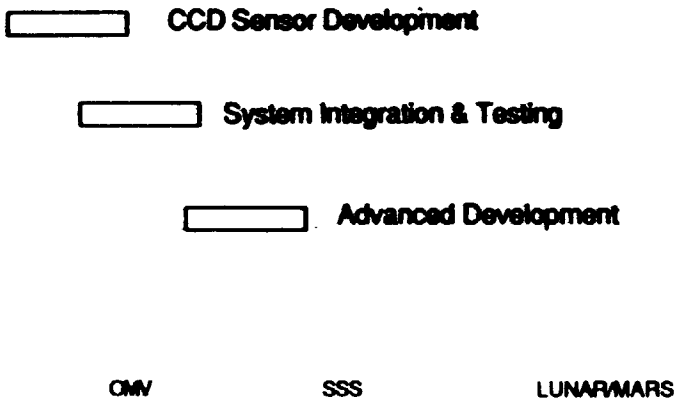
MAJOR ACCOMPLISHMENTS:

Software simulations of various docking/Berthing algorithms

Integrated large-scale hardware tests of system

Advanced algorithms developed and awaiting hardware testing

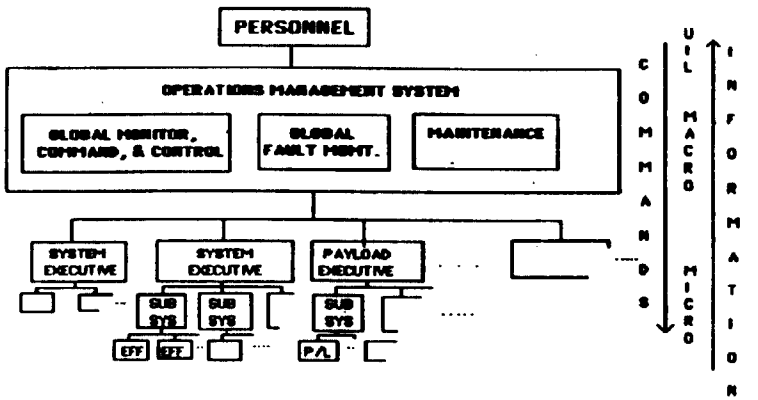
SIGNIFICANT MILESTONES:



SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
OPERATIONAL EFFICIENCY
OPERATIONS MANAGEMENT SYSTEM

NOVEMBER 1989

INTEGRATED COMMAND & CONTROL



MAJOR OBJECTIVES:

PROVIDE INTEGRATED ONBOARD COMMAND & CONTROL OF VEHICLE SYSTEMS.

USE AUTOMATED SYSTEMS TO REDUCE CREW WORK LOAD.

USE STANDARDIZED PROCEDURES TO REDUCE OPERATIONAL COMPLEXITY.

PROVIDE INTER-VEHICLE OPERABILITY BY USE OF COMMON COMMAND & CONTROL SOFTWARE.

REDUCE SE&I COMPLEXITIES BY USE OF STANDARDIZED HIERARCHICAL SOFTWARE STRUCTURES.

BUILD COMMAND & CONTROL SYSTEMS THAT CAN EVOLVE.

KEY CONTACTS:

A. BRANDLI / JSC / EH3
R. ECKELKAMP / JSC / FM4
D. OWENS / JSC / DS2
P. HARTLEY / GSFC / 512
L. HENSCHEN / MCDONNELL DOUGLAS
C. KELLY / MITRE
D. RUE / TRW
W. MCCANDLESS / LESC

FACILITIES :

OMS TESTBED
PMS TESTBED
VARIOUS CONTRACTOR TESTBEDS

MAJOR MILESTONES (OMS PROTOTYPES)

CONCEPTUAL STUDIES ('85 - 86')

STANDALONE PROTOTYPES ('86 - '87)
LISP, SYMBOLICS, 1ST DEMO 10-86

OMS INTEGRATED IN TESTBED PHASE 1 ('87 - '88)
WITH GN&C EMULATOR TEST BED FOR REBOOST, DEMO 1-88

OMS INTEGRATED IN TESTBED PHASE 2 ('89 - '90)
ADA, C ON MICROVAX, SUN WITH GN&C, TCS, C&T, GEPDC, MPAC

ADDITIONAL OMS FUNCTIONS & NODES ('89 - '91)
STATION SHORT TERM PLAN, REPLANNING, PAYLOADS

MULTIPLE VEHICLE OMS ('91 - ' 93)

SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
0PERATIONAL EFFICIENCY
OPERATIONS MANAGEMENT SYSTEM

NOVEMBER 1989

TECHNOLOGY ISSUES:

- RELIABLE EXPERT SYSTEMS FOR COMMAND & CONTROL
- SOFTWARE CAPABLE OF BEING TRANSFERRED AMONG SPACE PROGRAMS (E.G., PARTS LIBRARY, APPLICATIONS GENERATOR)
- PERFORMANCE OF MAINTENANCE CONCURRENT WITH OPERATIONS
- FLEXIBLE COMPUTER SYSTEMS ALLOWING TECHNOLOGY UPGRADES & MULTIPLE LANGUAGES
- ADVANCES IN SOFTWARE ENGINEERING METHODOLOGIES & IN OPTIMIZATION OF SOFTWARE STRUCTURES
- ADVANCED MAN-MACHINE COMMAND & CONTROL INTERFACES

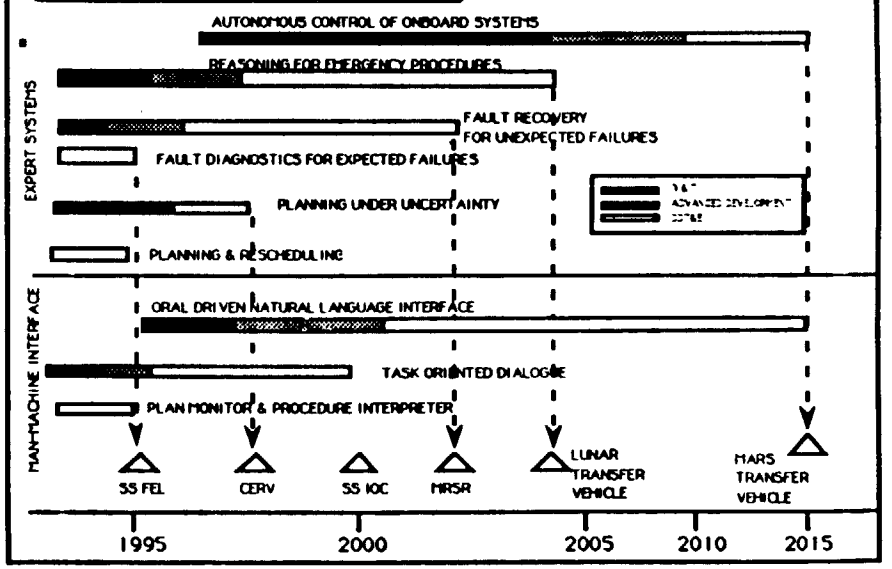
CANDIDATE PROGRAMS:

- CERV INCLUDING AUTOMATED ENTRY
- STATION OMS
- LUNAR / MARS INITIATIVE
- MARS SAMPLE RETURN MISSION
- NEXT GENERATION SHUTTLE
- NATIONAL AEROSPACE PLANE
- ADVANCED INTERPLANETARY PROBES
- POTENTIAL RETROFIT FOR NSTS GROUND
  - MAINTENANCE
  - GLOBAL FAULT MANAGEMENT

MAJOR ACCOMPLISHMENTS:

- HIERARCHIAL COMMAND & CONTROL ILLUSTATED IN OMS TESTBED
- MULTIPLE PROTOTYPES IN GLOBAL FAULT MANAGEMENT
- EXPERT PLAN GENERATORS
- PROTOTYPES IN PLAN EXECUTION, MONITORING, & REPLANNING
- MAINTENANCE PROTOTYPE BEING TESTED IN NSTS CONTROL CENTER
- OPERATIONAL REALTIME SYSTEM MONITORS
  ("INCO" AT JSC & "SHARP "AT JPL)

SIGNIFICANT MILESTONES:



SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
OPERATIONAL EFFICIENCY
ADVANCED TEST AND CHECKOUT SYSTEMS

NOV 1989, rev E

ADVANCED AVIONICS CHECKOUT CONCEPTS

TEST & CHECKOUT CAPABILITIES INCORPORATED IN BASIC SYSTEM ARCHITECTURE

AUTOMATIC, AUTONOMOUS TESTING
- ADVISORY DATA ONLY TO GROUND
- GROUND CONTROL OF INITIATION, MONITORING & SAFING

LIFE CYCLE COSTS DRIVE TECHNOLOGY SELECTION
- PROCESSORS, MODULAR SOFTWARE, MEMORIES

FAULT ISOLATION TO FAILED BOX OR CARD
- EXTENSIVE "BITE", EASY REPLACEMENT
- SMART SENSORS/EMBEDDED PROCESSORS
- EXPERT SYSTEM DIAGNOSTICS
- GO/NO-GO HEALTH STATUS REPORTING

BOTH IN-FLIGHT AND GROUND TESTING
- SYSTEM-LEVEL "END-TO-END" SELF TEST
- INDEPENDENT SUBSYSTEM VERIFICATION TESTING
- REDUNDANCY VERIFICATION AND TREND ANALYSIS

MAJOR OBJECTIVES:

REDUCE COST OF GROUND TEST AND CHECKOUT
- $, PERSONNEL, TIME

INCREASED AUTOMATION OF TEST AND CHECKOUT

INCREASED TESTABILITY OF SUBSYSTEMS AND LRU'S

ON-ORBIT DIAGNOSTICS AND READINESS VERIFICATION

APPLY TEST & CHECKOUT REQTS AT SYSTEM LEVEL
- AT START OF PROGRAM

KEY CONTACTS:

CHARLES TEIXEIRA, NASA/JSC

DON BROWN, NASA/JSC

CAREY MC CLESKEY, NASA/KSC

LEE SHOCKLEY, ROCKWELL/STSD

DICK THIEL, ROCKWELL/STSD

JIM TULLEY, LSOC/KSC

FACILITIES:

NASA & CONTRACTOR LAB FACILITIES
SUCH AS:
- JSC AVIONICS ENGINEERING LAB (JAEL)

MAJOR MILESTONES:

PROPOSED SHUTTLE EVOLUTION CHANGES ENHANCE T&C/O
- GLASS COCKPIT
- EMA
- INSTRUMENTATION UPGRADE

RAPIDLY ADVANCING EXPERT SYSTEM SOFTWARE

APPLICATION OF MIL SPECS ON TESTABILITY/BITE
- INCORPORATED IN MODERN BOXES/CARDS

AIRLINE & AIRFORCE IMPLEMENTATION OF ONBOARD TEST

SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
OPERATIONAL EFFICIENCY
ADVANCED TEST AND CHECKOUT SYSTEMS

NOV. 1989, rev E

TECHNOLOGY ISSUES:

ONBOARD VERSUS GROUND TRADES
- MANNED VS UNMANNED, EXPENDABLE VS REUSABLE

LIFE CYCLE COST ISSUES/TRADES
- GROWTH PROVISIONS & STANDARDIZATION
- LAUNCH WITH FAILURE
- COST OF BITE VS OPERATIONAL SAVINGS
- ACCESSIBILITY

SOFTWARE APPLICATION TRADES
- SOFTWARE CHANGE VERIFICATION ONBOARD
- EXPERT SYSTEMS, TRENDING, KNOWLEDGE CAPTURE

AVIONICS SYSTEM TRADES
- CENTRAL VS DISTRIBUTED PROCESSING
- SOFTWARE VS FIRMWARE
- LANGUAGE SELECTION

DATA STORAGE DEVICES
- OPTICAL DISK, BUBBLE MEMORY, MAGNETIC TAPE

CANDIDATE PROGRAMS:

SHUTTLE EVOLUTION
- EVALUATE FOR ALL PROPOSED SUBSYSTEM UPGRADES

ACRV (ASSURED CREW RETURN) (CERV)
- AUTOMATIC ONBOARD T&C/O WILL BE MANDATORY

SHUTTLE C
- LOW OPERATIONAL COST REQUIRES ADVANCED T&C/O

LAUNCH PROCESSING SYSTEM UPGRADE
- LPS UPGRADES SHOULD CONSIDER PLANNED VEHICLE TESTABILITY IMPROVEMENTS, AND VICE-VERSA

AMLS (ADVANCED MANNED LAUNCH SYSTEM)

PLS (PERSONNEL LAUNCH SYSTEM)

NASP (NATIONAL AERO SPACE PLANE)

MAJOR ACCOMPLISHMENTS

CONTINUING EVOLUTION OF ELECTRONICS EXPANDS AVAILABLE SOLUTIONS
- ONBOARD COMPUTATIONAL AND MEMORY CAPABILITIES ARE REALIZABLE
- OPTICAL BUSES & MEMORIES PROVIDE CAPABILITY TO HANDLE LARGE DATA BASES

GOVERNMENT SPONSORED PROGRAMS SUPPORT BITE, MODULARITY AND DISTRIBUTED PROCESSING
- MISSION CONTINUATION WITH FAILURES (ROBUSTNESS)
- ACCESSIBILITY (RACK MOUNTED CARDS/BACK PLANE)

ARTIFICIAL INTELLIGENCE (AI) APPLICATIONS CONTINUE TO EXPAND
- SUPPORTS ONBOARD DIAGNOSTIC DEVELOPMENT

SIGNIFICANT MILESTONES:

TEST & CHECKOUT SOFTWARE VERIFICATION AND MAINTAINANCE COST CONTAINMENT METHODOLOGY

DEVELOP REALISTIC LIFE-CYCLE COST ANALYSIS TECHNIQUE

FURTHER DEVELOPMENT OF AI FOR COMPLEX SYSTEMS

INVESTIGATION OF PACKAGING TECHNIQUES FOR RAPID ACCESS FOR R&R

SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
OPERATIONAL EFFICIENCY
ADVANCED MISSION CONTROL

TECHNOLOGY CONCEPT:

- Intelligent Assistance for Ground-Based Mission Controllers and Space-Based Crew
- Autonomous Onboard Monitoring, Control, and FDIR
- Dynamic Corporate Memory Acquired, Maintained, and Utilized During Entire Vehicle Life-Cycle

MAJOR OBJECTIVES:

- Reduced Manpower Needs
- Reduced Training Time
- Improved Critical Decision-Making
- Enhanced Mission Safety by Discovery of Incipient Failures
- Free Crew to Conduct Mission Tasks
- Provide Realtime Capabilities Beyond Human Performance Levels
- Capture Knowledge Throughout Design, Construction, Test, and Operations
- Provide Focused Problem-Solving Capability

KEY CONTACTS:

P. Friedland/ARC
J. Muratore/JSC
A. Heard/KSC
D. Atkinson/JPL
M. Montermerlo/HQ-RC
G. Swietek/HQ-ST
C. Holliman/HQ-MD

S. Cross/DARPA
M. Benda/Boeing
C. Hall/Lockheed

KEY FACILITIES:

ARC Laboratory-ASRF
JPL Laboratory

MAJOR MILESTONES:

- Review Experience in Launch and Mission Control Automation at JSC, KSC, and JPL. Determine Major Areas of Technology Integration and Improvement (1990).
- Demonstrate Techniques on SSF testbeds and on STS non-mission-critical experiments (1991-1993).
- Determine Technology Utilization Plan for Lunar/Mars Exploration Missions (1990-1995).

SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
OPERATIONAL EFFICIENCY
ADVANCED MISSION CONTROL

TECHNOLOGY ISSUES:

- Correct Mix of Humans and Machines for Decision Support
- Integration of Artificial Intelligence and Advanced Interaction Concepts (Hypermedia, Direct Interaction Devices, Multi-Media, etc.)
- Hardware and Software Environments for Realtime Onboard Behavior
- Data Storage and Realtime Access for Very Large-Scale Corporate Memory Systems
- Knowledge Acquisition and Maintenance during Long-Term Missions
- Qualitative Reasoning about Complex Systems

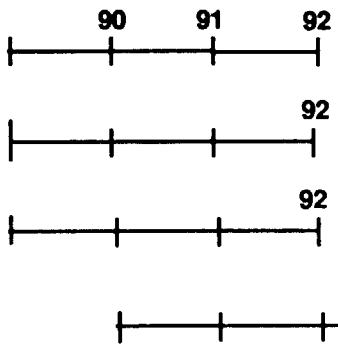
CANDIDATE PROGRAMS:

- SSFP (Onboard, TMIS, and SSCC)
- ALS
- NSTS
- Lunar/Mars Missions

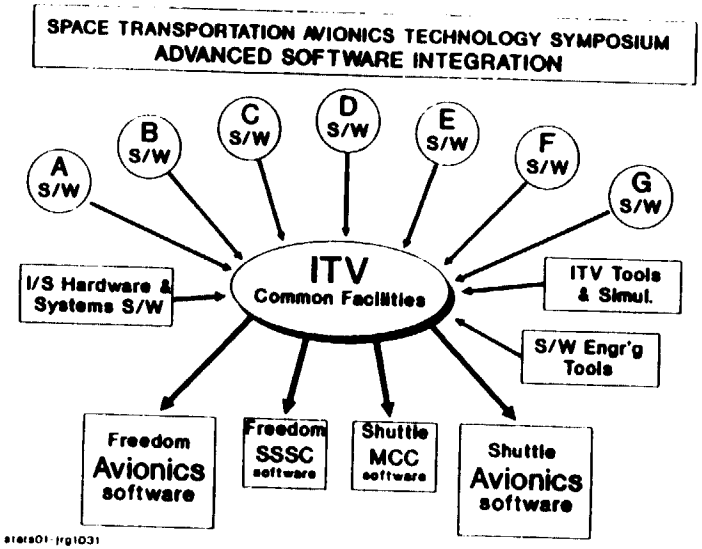
MAJOR ACCOMPLISHMENTS:

- Use of Advanced Automation in MCC at JSC and During Voyager Neptune Flyby at JPL
- World-Class Laboratories at ARC and JPL
- SSF Advanced Development Program Tasks
- Full Integration with DARPA and AF Programs

SIGNIFICANT MILESTONES:



Advanced Software Integration



Major Objectives

- Maintaining reliability in increasingly complex software and information systems (contrasts in STS and SSFP avionics).
- Enabling evolution (functionality, technology, connectiveness) in systems which are now "never-ending".
- Managing increasingly distributed work-packets and efforts in the development of applications software for the advanced systems.
- Reuse and commonality (across systems and programs) both an operations efficiency (training, management, etc.) and as a productivity item.

Key Contacts & Facilities

Contacts:

John R. Garman/JSC(FA)
Ed Chevers/JSC(FR)
Rick Coblentz/JSC(FR)
Jack Seyl/JSC(FS)
Charles McKay/UHCL (JSC)

Facilities:

Information Systems Technology Lab (ISTL)/JSC(FA)
Avionics Development Lab (SSFP/WP2)/JSC(FR)
Software Development Facility (NSTS)/JSC(FR)
Support Software Environment Development Facility (SSEDF)/JSC(FR)
Mission Systems ITV Facility/JSC(FS)

Major Milestones (1990-1995)

- Operation of STS SAIL and SPF (1976)
- SSE Baseline for SSFP (1990)
- Avionics Integration and ITV baseline for SSFP (1990)
- Mission Systems ITV (MSITV) Facility Design (1990)
- ADF and MSITV FOC (1992)
- Shuttle and SSFP ITV commonality (1997)

Advanced Software Integration (cont'd)

Technology Issues

- Containment of growing drivers: complexity, connectivity, security, and architectures
- Standardization of I/S "layers" - industry standards
- Virtual target environments (exact simulation of target platform allowing diagnostics)
- "Project Object Database" - the database and management technologies involved in creating a single unambiguous image of the entire distributed software system
- Integration of heterogenous products designed against common standards (both the host and target domains)
- Software Lifecycles modeled against evolutionary development and maintenance (vs. waterfall)

Candidate Programs

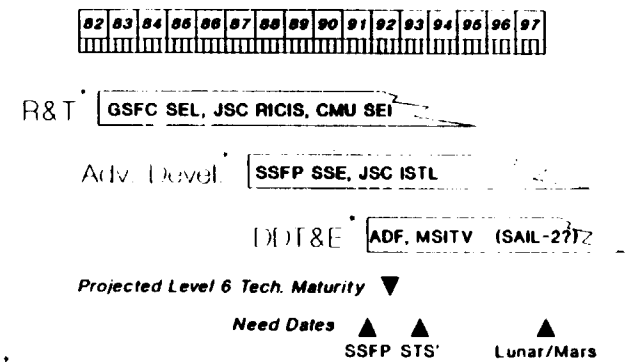
- NSTS Avionics Flight Software
- NSTS Mission Control Center Upgrade
- NSTS Other I/S
- SSFP Data Management System (avionics)
- SSFP Mission Control and Trainers
- SSFP Other I/S
- Advanced Programs (Lunar/Mars)

Major Accomplishments/"Inabilities"

✓ Major Accomplishments
- Establishment of RICIS
- Establishment of SSE development effort
- Baselining of commonality in applications tools and UI for SSFP
- Industry evolution toward standardization of I/S layers

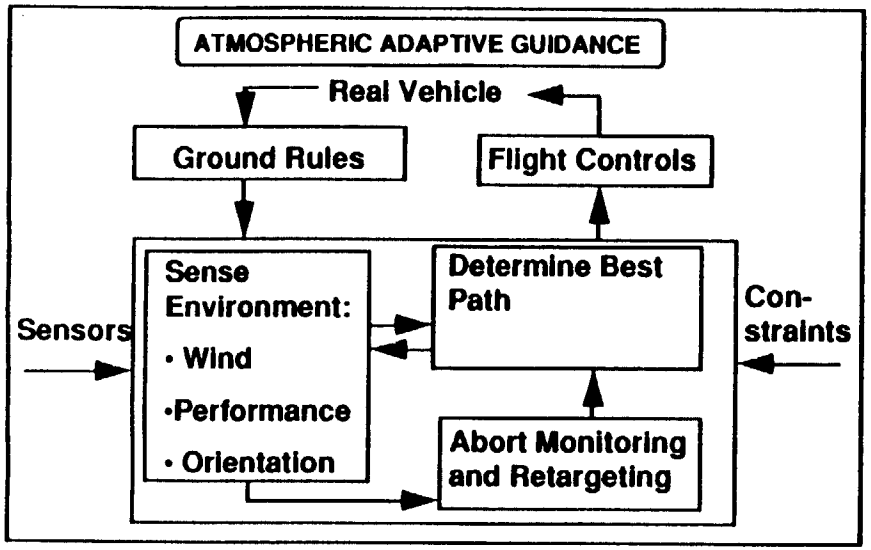
✓ Major "Inabilities"
- Duplication of effort across Programs/Projects
- Proliferation of mission supporting software
- Inability to fully utilize COTS
- Inability to upgrade existing capabilities

SIGNIFICANT MILESTONES Advanced Software Integration



SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
OPERATIONAL EFFICIENCY
ATMOSPHERIC ADAPTIVE GUIDANCE

NOVEMBER 1989



MAJOR OBJECTIVES:

- Improve Safety Margins
- Reduce Costs/Time Associated with Pre-Launch Planning
- Improve Vehicle Performance and Increase Launch Probability
- Minimize Required DOL Ground Support
- Increase Weather Envelope

KEY CONTACTS:

- Douglas Price/LaRC
- David Long/JSC
- Daniel Moerder/LaRC
- David Geller/JSC

MAJOR MILESTONES (1990-1995):

- Algorithm Feasibility Investigation (1989)
- DOL I-Load Update Implementation (1990)
- Advanced Wind Measurement System (1992)
- Onboard Algorithm Dev. (1992)
- Advanced Flight/Space Rated Computers (1994)

SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
OPERATIONAL EFFICIENCY
ATMOSPHERIC ADAPTIVE GUIDANCE

NOVEMBER 1989

TECHNOLOGY ISSUES:

- Partitioning of Guidance Between Ground and Vehicle
- Onboard Guidance/Control Algorithm Sophistication
- Wind Knowledge Required
- Onboard Sensor Capabilities
- Computational Capability Required

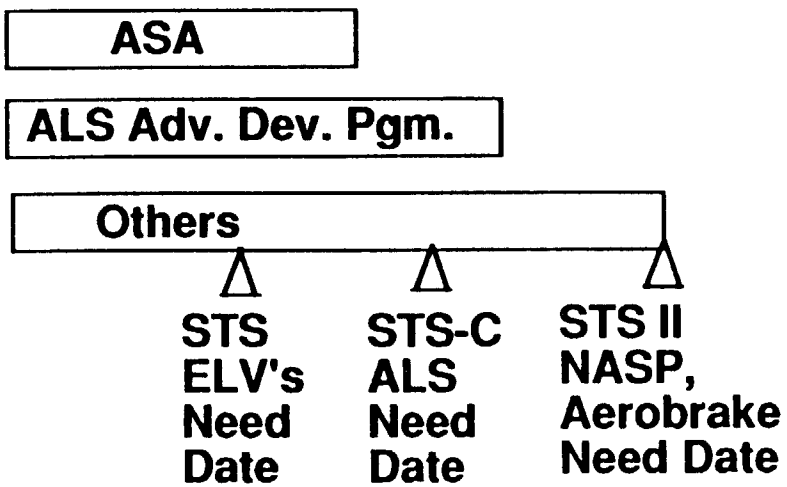
CANDIDATE PROGRAMS:

- Assured Shutle Availability (ASA)
- Shuttle-C
- Advanced Launch System (ALS)
- ELV's
- Shuttle II
- Lunar/Mars Missions (Aerobrake)
- NASP

MAJOR ACCOMPLISHMENTS:

- STS Alternate I-Loads Capability
- STS Adaptive Guidance Throttling
- ALS Onboard LIDAR Wind Mapper/Adaptive Trajectory Sampling Feasibility & Benefit Study
- KSC Statistical Wind Simulation Model for Synthesizing Launch Wind Profiles

SIGNIFICANT MILESTONES:



SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMNPOSIUM
OPERATIONAL EFFICIENCY

Health Status and Monitoring

ADVANCED HS&M CONCEPTS

- PAPERLESS LIQUID ROCKET ENGINE HISTORY ANDMAINTENANCE PROCEDURES
- MAINTENANCE ON DEMAND
- INTEGRATED VEHICLE HEALTH MANAGEMENT WITH ROCKET ENGINE HEALTH MONITORING
- UTILIZE ON BOARD HS&M CAPABILITIES FOR GROUND TEST
- MINIMIZE GSE

MAJOR OBJECTIVES:

- PROVIDE VISIBILITY INTO SYSTEM READINESS
- REDUCE COST OF PRE-FLIGHT CHECKOUT AND POST-FLIGHT MAINTENANCE
- INCREASE PROBABILITY OF MISSION SUCCESS

ADVANCED HS&M CONTACTS

AEROJET	- CARRIE KOECHEL
ROCKETDYNE	- ARNIE NORMAN
PRATT & WHITNEY	- JOSEPH BAKER
ASTRONAUTICS LAB	- ROBERT VACEK
NASA LeRC	- LARRY COOPER
NASA MSFC	- W.T POWERSEL
NASA JSC	- T. BARRY
IBM	- L. SMALL
HARRIS	- R. MONIS
BOEING	- JEFF ALBERT
GENARAL DYNAMICS	- JOSEPH JOHNSON
MARTIN MARIETTA	- RON PUENING

MAJOR OBJECTIVES:

- SSME SAFETY MANAGEMENT -1994 (OPEN LOOP ENGINE TEST)
- SPACE TRANSPORTATION ENGINE PROGRAM
  - DESIGN CONCEPT REVIEW 3/90
  - MIDTERM DEFINITION REVIEW 1/91
  - FINAL PROJECT REVIEW 9/92
- ALS INITIAL LAUNCH CAPABILITY 1998

SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMNPOSIUM
OPERATIONAL EFFICIENCY

Health Status and Monitoring

TECHNOLOGY ISSUES:

- SENSOR DEVELOPMENT
- SENSOR/COMPUTER INTERCONNECT DEVELOPMENT
- COMPUTER I/O (MODULARITY)
- GENERIC HEALTH MONITORING ARCHITECTURE
- HEALTH MONITOR/SYSTEM INTEGRATION & SIMULATION (GROUND AND ON BOARD)
- ALGORITHM/SOFTWARE DEVELOPMENT
- DATA PROCESSING
- VEHICLE AVIONICS COMMONALITY

CANDIDATE PROGRAMS:

- SPACE TRANSPORTATION ENGINE PROGRAM
- ADVANCED LAUNCH SYSTEM PROGRAM
- PATHFINDER PROGRAM
- EARTH-TO-ORBIT
- NASP
- NSTS UPGRADES
- LUNAR/MARS EXPLORATION INITIATIVES
- CERV

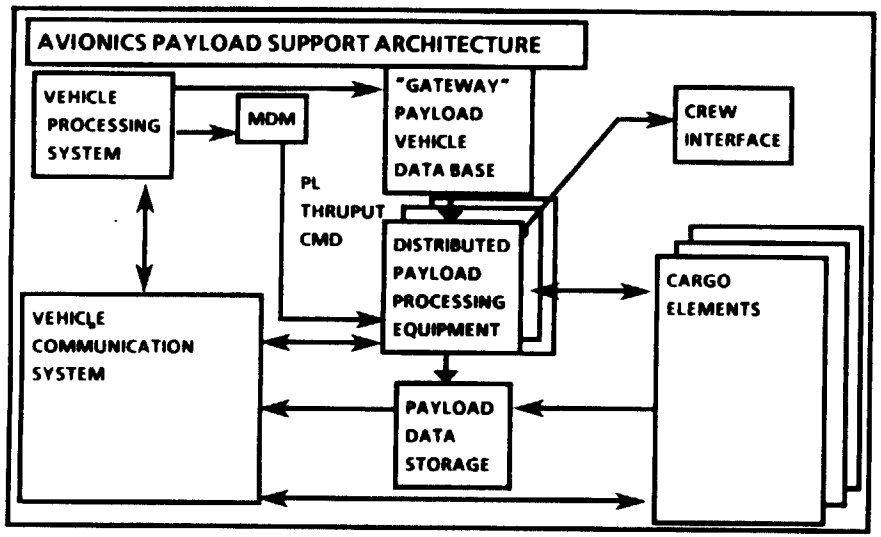
MAJOR ACCOMPLISHMENTS:

- NASA LeRC
  - ROCKET ENGINE LIFE PREDICTION AND MODELING
  - REUSABLE ROCKET ENGINE DIAGNOSTIC SYSTEM DESIGN
  - ADVANCED MASS STORAGE
  - REUSABLE ROCKET ENGINE TRUBOPUMP HEALTH MANAGEMENT SYSTEM
- NASA
  - MSFC/SSME HEALTH MANAGEMENT
  - JSC/SPACE STATION
- USAF - (AL)
  - ROCKET ENGINE CONDITION MONITORING
  - VEHICLE HEALTH MONITORING SYSTEM

SIGNIFICANT MILESTONES:

- ESTABLISH & MAINTAIN FUNDING
- SPACE STATION PDR - 1990
- VERIFY ENGINE / SENSOR FAILURE DETECTION - 1990
- DEMONSTRATE ALS HEALTH MONITORING TECHNOLOGIES - 1993
- EXPERT SYSTEMS (LIFE PREDICTION) - 1993

SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
PAYLOAD ACCOMMODATIONS
AVIONICS PAYLOAD SUPPORT ARCHITECTURE



MAJOR OBJECTIVES:

- RELIABLY PROVIDE SERVICES TO PAYLOAD CUSTOMERS TO MEET THE EXPECTED REQUIREMENTS (EXPANDED COMMAND, TELEMETRY, VIDEO SERVICES, ONBOARD DATA STORAGE CAPABILITY, "GATEWAY" TO VEHICLE DATA)
- REDUCE LABOR INTENSIVE INTEGRATION/RECONFIGURATION/OPERATIONS/TRAINING
- REDUCE INTERDEPENDENCE OF VEHICLE AND PAYLOAD
- PAYLOAD SERVICES ARCHITECTURE SHOULD UTILIZE GOVERNMENT/INDUSTRY STANDARDS, E.G., 80386 PROCESSOR, 1750A PROCESSOR, 1553 DATA BUS, ETC.
- PROVIDE PROGRAM INTERCHANGEABILITY OF COMPONENTS AND CAPABILITY TO EASILY UPGRADE SYSTEM AS NEW CAPABILITIES ARE DEVELOPED.

KEY CONTACTS:

STAN BLACKMER/JSC/TJ (STS)
BILL MALLARY/JSC/EH (SSF)
NED TRAHAN/JSC/EH
C. D. LEVY/MMC
S. L. CREASY/JSC/DH6

MAJOR MILESTONES:

- PROVISION FOR USE OF PAYLOAD AND GENERAL SUPPORT COMPUTER (GRID 1530) FOR PAYLOADS ON THE STS
  - ICD, USER GUIDELINES-1989
  - FEA, PM-1989
  - USE WITH TSS-1991
  - NUMEROUS SECONDARY PAYLOADS FROM 1990 ON
- SSF PAYLOAD SUPPORT ARCHITECTURE DEFINITION/DESIGN
- SHUTTLE-C PAYLOAD SERVICES DEFINITION